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Office Memorandum • UNITED STATES GOVERNMENT

TO : Assistant Director/Scientific Intelligence   DATE: 25 November 1957

FROM : Chief, Fundamental Science Division/SI

SUBJECT: Soviet Research on Desalination of Water

SUMMARY

Soviet research on the desalination of water appears parallel with similar research in the United States. Because of a different economic basis, and a difference in underlying philosophy, it is rather difficult to compare such research. In both countries the major portion of the scientific and engineering research on saline water conversion is aimed at supplying water for industrial uses, such as power plants, process water, etc., rather than for agricultural or human use. However, in the U.S. the final cost of the water is the governing factor, whereas in the Soviet Union the final cost is only one factor. The processes investigated by the Soviets, arranged roughly in the order of the amount of research accomplished in each, are: fuel heat distillation, chemical processes, natural freezing processes, electrodialysis, solar distillation, and natural temperature processes.

We have no reason to believe that the Soviets have advanced their technology significantly beyond that of the United States in any of these fields. To quote a summary of the recent symposium held in Washington, D.C., "Substantial progress in improving processes for converting saline water has been made but large-scale conversion plants furnishing potable water at economic prices are not just around the corner."

DISCUSSION

In the United States, distilled water from saline sources has been produced for many years, primarily by evaporation (distillation) processes. In the past this water has been utilized mainly for industrial purposes, although some smaller cities have also been supplied with such water for human needs. Present research work in the United States is centered in the efforts of the Office of Saline Water, Department of the Interior. Since 1952 this Office has made rather intensive surveys of virtually all proposed methods of desalting water, and has encouraged and supported governmental, institutional and industrial research in this field. Present indications are that the five most competitive methods involve: distillation, solar distillation, electrodialysis, osmosis and freezing.

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Best current estimates are that water for specific industrial uses might cost as much as $3.00 per 1000 gallons, whereas the top figure for municipal use is $0.35 per 1000 gallons and for irrigation, $0.12 per 1000 gallons. Based partly on research estimates and partly on production data, current U.S. estimates for the best processes are as follows:

(a) Distillation - $0.30 to $2.00/1000 gallons

(b) Solar distillation - $1.00 to $6.00/1000 gallons

(c) Electrodialysis - $0.30 to $1.00/1000 gallons

(d) Freezing processes - $2.00/1000 gallons

It is clear that at present no projected process is capable of producing useable water at the price deemed necessary for irrigational uses ($0.12 per 1000 gallons).

For the future, the Office of Saline Water is working towards:

(a) More money from Congress.

(b) A survey to determine the water needs of all areas of the U.S.

(c) Continue fostering research toward industrial and municipal uses.

(d) Increased participation in foreign projects.

In the USSR, as in this country, there are vast arid and semi-arid areas (Central Asia, Western Siberia, coastal region of the Caspian Sea, and others) for which efficient and economical saline water conversion processes are of vital importance. And also as in the United States, the main body of scientific and engineering research on saline water conversion has been done for industry, for its steam power plants and water supply, rather than for agricultural and drinking purposes. This similarity has led the United States and the USSR to the creation and construction of similar processes and devices. In general, the same research areas have been investigated, although somewhat different processes and apparatus have resulted.

According to Russian sources, saline water conversion by solar heat was in operation as early as 1872, and the Russian army used fuel heat distillation in 1881. One of the world's largest saline water conversion plants of the time was built at Baku City in 1898-1899, with an estimated output of 270,000 gallons of fresh water per day.

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In recent years the USSR has expanded considerably its areas of research, utilizing the efforts of numerous organizations, including the Krzhizhhanovsky Institute of Energetics of the USSR Academy of Sciences, the All-Union Thermo-technical Institute, the Leningrad Chemical-Technical Institute, the Azarbeijan Industrial Institute, and others. In many cases, the problem of saline water conversion has been considered to be of more local than national interest. As a result, a considerable amount of information has been published by regional research institutes, the results of which have not been widely disseminated.

Thermal Methods of Desalting

Included in this classification are processes in which water changes its aggregate state either by vaporization or by freezing. The latter is the older process, used by the natives of Central Asia and Western Siberia from ancient times. The former is the most widely used and is still the most important process by far of all of the processes for converting saline water to fresh water.

In most of the various methods of distillation by vaporization, the process efficiency suffers from the formulation of scale in the boilers and evaporators. Prevention and economical removal of scale and sludge are items of major research in the United States, the United Kingdom, and the USSR. Most of the books published by the Soviets on water treatment for steam power or industrial water supply contain special chapters on the prevention of scale and corrosion. Soviet research has covered such methods as the precipitation and filtration of gypsum, electrical cathode protection, and the use of anti-scales, such as proteins, cellulose derivatives, and tannic acid.

Single and multiple effect evaporation is the most common method of saline water conversion today as it was 50 years ago. A four-stage desalination was in operation at Bibi-Eibat in Central Asia in 1902. Similar units were built at Krasnovodsk in 1904 and Vladivostok in 1905. Vapor-compression desalination is known as thermal compression in the USSR and it is claimed to have been invented by a Russian engineer (Bessonov) in 1904. Auxilliary units in the form of turbo-compressors, steam injectors, and piston pumps have been added in more recent years. Both horizontal and vertical types of evaporators have been used. Little research is indicated in the current Russian literature, although minor improvements are probably being made regularly at the plant level.

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Considerable Soviet research has been devoted to single stage vacuum desalting, often with external preheating. Fuel, electricity, and solar energy have been utilized as heating means. Although the cost of producing water by this method appears encouraging, the process seems to be limited to moderate size units, and requires vacuum-tight equipment. This process apparently has no great future as a saline conversion method in the USSR.

Much of recent published research involves Soviet efforts to utilize solar energy for the production of steam power or fresh water. Research in the field is led by Dr. of Tech. Sci. V.A. Baum, head of the Heliotechnical Laboratory of the Krzhizhanovsky Institute of Energetics in Moscow.

In 1954, Baum presented a paper at the Symposium on Solar Energy and Wind Power held in New Delhi, India. In this paper he described work being done at the Tashkent station of the Heliotechnical Laboratory. The most notable revelation involved the development of a solar boiler utilizing paraboloid reflectors 10 meters in diameter which produced a reported 130 lb. of steam per hour at a pressure of 100 lbs. per square inch. This boiler served as a model for the construction of a large scale solar still claimed to produce approximately 270 gallons of distilled water per day. It was said that this device was being used to water livestock in the remote and arid Karakum desert. A diagramatic scheme of the installation of this boiler is included in the Proceedings of the Phoenix Symposium on Solar Energy (1955).

In addition, there were reports by Baum of portable solar furnaces designed for families of three to four people which could boil six litres of water an hour, cook a meal, and distill six litres of water a day. A photograph of a small salt water still is analyzed in the Graphics Register (150573).

Recent articles by Baum and a paper by him delivered in absentia at the World Symposium on Applied Solar Energy held in Phoenix in 1955 were primarily concerned with his design for a relatively grandiose heliostation. This power station, involving some 1293 individual flat reflectors mounted on 23 concentric railway lines about an elevated boiler, was claimed to be capable of providing irrigation in summer and heat in winter for 17 thousand inhabitants. Its proposed use for irrigation purposes apparently involved only the pumping of underground water for that purpose and did not envision the conversion of saline water.

On March 7, 1957, Baum was received by the Egyptian Research Center and reportedly informed the Egyptians as to the latest developments of solar energy production and employment in the Soviet Union. This may have some significance in view of the statement by an Egyptian delegate at the New Delhi Symposium that Egypt's principal concern with solar energy focused on the conversion of salt water to fresh.

Baum, himself, has been characterized as a "power engineer of considerable competence" whose appearance and paper at the New Delhi Symposium had quite an impact on Western scientists. There has been conjecture that perhaps the apparent lack of real appreciation of his talents in the USSR reflects the low priority given to his projects and the Heliotechnical Laboratory. Western estimation of his work has lowered somewhat as a result of his paper delivered at the Phoenix Symposium as his designed heliostation was considered largely visionary.

In all of this work on the utilization of solar energy, desalting of water occupies an apparently incidental position. Touching briefly on the subject in his Phoenix paper, Baum concluded that distilling water by means of the solar still described above "would be profitable only where fuel is expensive and sources of fresh water far removed."

(In the United States, as a result of recent research, solar energy appears less and less promising as a means of desalination of water. Equipment and maintenance costs are high and the output is considered moderate.)

An interesting method of desalination was attempted by N.A. Fedoseev, termed "surfaceless" desalination. This method consists of spraying saline water directly into a burning furnace. The total surface area of such droplets is large, the rate of evaporation is therefore high, and there is no heat transfer surface on which scale can collect. The Soviets appear to have abandoned this process because of a large moisture carry-over to the atmosphere, and bulky construction.

Few recent researches in the USSR have been reported on in desalting by freezing. This process has been used from ancient times by various people when living in a dry climate having cold, frosty nights. The salt water is run into ditches laid with stone or boards, and after partial freezing, the ice is removed to other ditches or containers. A number of research organizations in the USSR worked on this process during the 1930's and 40's, without any outstanding success.

Chemical Methods of Desalting

Little research up to the present has been done in the USSR on desalination of water by precipitation. However, an intensive effort appears underway in the field of ion exchange. Despite this effort, it is extremely doubtful that the Soviets are utilizing ion exchange resins for desalting water on a large scale in any large Soviet installation. It is highly unlikely that the Soviets at present have the ion exchange resins or the know-how, to produce a facility capable of desalting sea water on such a scale.

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The principal application for ion exchange resins in the USSR at the present time appears to be in the field of water purification for use in high pressure turbines used to generate electric power. This process appears to be one of demineralization from normal water rather than one of desalting from a high salt-content water. The use of ion exchange resins, however, appears to be a popular topic.

The Soviet press has, on several occasions, pointed out that ion exchange resins would be used to purify the water abundant in many of the Soviet "virgin lands" where the water, because of its salt content, cannot be used. The press has also criticized the Ministry of Chemical Industry for not producing enough ion exchange resins.

Basic research on ion exchange resins is being conducted at the Institute of High Molecular Compounds, Moscow, the Vinogradov Institute, and the Institute of Physical Chemistry i/m Karpov-Moscow. The following two organizations have probably done the most applied research in connection with demineralizing or desalting of water: Section of Water Treatment, Commission on High-Pressure Steam, Institute of Power Engineering, USSR, Academy of Sciences; and Commission on Chromatography attached to the Department of Chemical Sciences, USSR, Academy of Sciences.

Ion exchange resins alone have not proven economical nor practical for desalting water in the United States. It is believed that they would have no added economic advantage for the Soviets.

There is one feature distinctly in favor of the use of ion exchange resins for water desalting if cost is not of great importance and a large percentage of the purified water could be sacrificed in the regeneration process. It is that no power such as heat or electricity is required nor is the equipment complicated and expensive to design and operate.

Desalting by Electrodialysis.

There are indications of a growing interest in the USSR in the desalting of water by electrodialysis (use of a membrane and an electrical force). The major research effort appears directed toward the production of boiler feed water for electric power plants, using electric current from the plant during low load periods. The All-Union Thermo-technical Institute has developed a multi-stage cylindrical desalter using ceramic membranes. The Leningrad Chemical-Technological Institute has produced a unit having cellulose acetate gauze separated by paper interlayer for its cathode membrane, and several layers of bakelite paper for the anode membrane.

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Although much work apparently remains to be done, it is of interest to note that a three million gallon a day electro-dialysis plant (non-Soviet) will go into operation next year in the Orange Free State, South Africa, to desalt gold mine water.

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